

VASCULAR EPIPHYTES OF SINGAPORE'S WAYSIDE TREES

by

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INTRODUCTION

The planting of wayside trees in Singapore has been going on since the turn of the last century. Most of these trees have been exotic, while a few, indigenous. One old favourite is the *angsana*, *Pterocarpus indicus* Willd., a native of Peninsula Malaysia (Burkill, 1935). This tree provides excellent shade and was thus planted extensively along many roads. However, around 1914 there was an outbreak of a disease resembling that of the European elm variety. One by one these trees became infected and rows of them were cut down in an effort to contain the disease, but in vain (Furtado, 1935). Only a limited number of trees survived, scattered around the island. The three big trees at the Esplanade by Anderson Bridge are among these (Corner, 1952). Another common wayside tree is the mahogany, *Swietenia macrophylla* King. This tree was first introduced into the country from Sri Lanka in 1876 (Burkill, 1935). Around 1930-40 these trees were planted along many roads. Most are still in existence today. Grown alternately with these trees along most of these roads were the *jambu laut*, *Eugenia grandis* Wight. A native of Peninsula Malaysia, this tree was adopted in 1882 as a fire break and planted along those roads bordering *lalang* wastes and subjected to regular fires (Burkill, 1935). The only road left with an entire row of *jambu laut* along both sides appears to be Dalvey Road.

The rain tree, *Enterolobium saman* Prain ex King, which has an umbrella shape and casts excellent shade, has been in Singapore since 1876 when it was introduced from its native South America (Burkill, 1935). The tree has proved to be popular ever since and avenues of different ages of trees can be found in many parts of the island. On the other hand the *tembusu*, *Fagraea fragrans* Roxb., which is of Indo-Malaysian origin, was grown for its majestic beauty along the older roads and in private compounds. Today, old trees can be found mainly around the Tanglin areas. Another popular tree, the *batai*, *Albizia falcataria* (L.) Fosberg, is fast growing and provides excellent shade. However, these trees are susceptible to damage by storms due to the shallowness of the root system and the softness of the wood. Because of this it has become unpopular and today a few old trees can still be found by certain roads while others are found growing wild in abandoned lands. The common *ru*, *Casuarina equisetifolia* J.R. & G. Forst., native to this region and a pioneer on sandy coast, was once extensively grown along Tanjong Rhu (Ridley, 1900), but no more. It was also once popularly grown in private compounds. It casts little shade but makes excellent wind-breaks. It is not commonly planted today but a substantial number can be found scattered around the island.

The population of Singapore's wayside trees has increased considerably since 1967 when the Government embarked on a campaign to turn the Republic into a garden city. Since then more than a quarter million trees have been planted (Anon., 1977). The current favourite is still the *angsana*, as besides

being a good shade tree, planting materials are abundant as cuttings strike root without difficulty. Other species of wayside trees include the yellow flame, *Peltophorum pterocarpum* Backer ex Heyne; the acacia, *Acacia auriculiformis* A. Cunn. ex Bth; the royal palm, *Roystonea regia* (H.B.K.) D.F. Cook and the flame of the forest, *Delonix regia* (Bojer ex Hook.) Rafin, among others.

Many of the wayside trees are infested with epiphytes, the older more so than the younger. Again, certain species of trees appear to be more heavily infested than others. On the other hand there are many trees that are entirely bare of epiphytes. According to Richards (1939) effective colonization by epiphytes only begins in the middle and late life of the trees. Working with two common wayside trees in Singapore, Johnson & Awan (1972) found that certain epiphytic species showed preference for host trees, probably because of their bark characteristics. In an effort to understand more about the epiphytic populations of the wayside trees, a qualitative survey was initiated in 1977 to study the distribution, species composition and association with the host trees. It is hoped that this study would lead to further work on the various quantitative aspects as well as on the autecology of the epiphytic species.

MATERIALS AND METHODS

Observations were made on the occurrences of vascular epiphytes on 11 common wayside trees along various main roads in Singapore. Only the number of species per tree was noted, no attempt was made to include quantitative information. The diameter of the tree trunk at breast height was recorded in every case. Trees with a diameter of less than 30 cm were excluded as these were considered too young to harbour any epiphytes. Each tree was examined from the ground. In most cases it was easy to identify the epiphytes as they usually occurred on the lower and bigger branches. The only difficulty was with *Pyrrosia*. Except for *P. longifolia* (Burm.) Morton with its distinctive long fronds, the other species like *P. varia* (Kaulf.) Farwell, *P. adnascens* (Forst.) Ching and *P. angustata* (Sw.) Ching could not be identified as the plants were sterile at the time of the survey. These were thus grouped under *Pyrrosia* spp. The species of trees examined were:

	No. trees observed
<i>Enterolobium saman</i> Prain ex King	160
<i>Eugenia grandis</i> Wight	223
<i>Swietenia macrophylla</i> King	217
<i>Peltophorum pterocarpum</i> Backer ex Heyne	96
<i>Fagraea fragrans</i> Roxb.	150
<i>Pterocarpus indicus</i> Willd.	138
<i>Acacia auriculiformis</i> A. Cunn. ex Bth.	122
<i>Casuarina equisetifolia</i> J.R. & G. Forst.	144
<i>Cocos nucifera</i> L.	200
<i>Albizzia falcata</i> (L.) Fosberg	89
<i>Roystonea regia</i> (H.B.K.) D.F. Cook	154
TOTAL	1,693

RESULTS AND OBSERVATIONS

The highest number of epiphytic species was recorded on *E. saman*. Of these 18 species, 11 were ferns and the rest phanerogams (Table 1). In addition, five species of phanerogams, not usually epiphytic, were found growing on the wayside trees examined. *Asplenium nidus* Linn., *Davallia denticulata* (Burm.) Mett., *Drymoglossum piloselloides* (Linn.) Presl. and *Pyrrosia* spp. were the common ferns and *Dendrobium crumenatum* Sw., the pigeon orchid, the common phanerogam. *Bulbophyllum vaginatum* (Lindl.) Rehb. f., another orchid, was common on *E. grandis*. The strangling figs, represented by *Ficus religiosa* Linn. and other *Ficus* spp. were reasonably common on most trees.

There was evidence of epiphytic preference for specific wayside trees. *Dischidia nummularia* R.Br. and *D. rafflesiana* Wall. were commonly found on *P. pterocarpum*; *B. vaginatum* on *E. grandis*; *Drynaria sparsisora* (Desv.) Moore on *E. saman*; *P. longifolia* on *F. fragrans*; and *Vittaria ensiformis* Sw. on *E. saman* and *E. grandis*.

Platynerium coronarium (Koenig) Desv., the stag's horn fern, at one time common, is now getting rare. Isolated plants were encountered on *E. saman*, *E. grandis*, *F. fragrans*, *A. auriculiformis* and *C. equisetifolia*. Of the total of 1693 trees examined, only 8 or slightly less than 0.5% had this fern on them.

Generally, the abundance of epiphytic species depended on the species of the wayside trees (Fig. 1). *E. saman*, *E. grandis* and *S. macrophylla* were more heavily infested with epiphytes than the other wayside tree. About 58% of *E. saman* and *E. grandis* trees sampled had three or more epiphytic species while the figure for *S. macrophylla* is 41%. With *P. pterocarpum*, *F. fragrans*, *P. indicus* and *A. auriculiformis*, about 69%, 55%, 55% and 56% respectively of the trees sampled had epiphytes on them. In the case of the other tree species, most of the trees had no epiphytes at all.

Older trees were more prone to epiphytic infestation than younger trees. Age was estimated from tree trunk diameter and only trees with a trunk diameter at breast height of more than 30 cm were included in the survey, as those with a lesser diameter invariably had no epiphytes on them. Thus those trees that were observed were at least 10–15 years old, as growth in diameter of these trees was estimated to be not more than 3 cm per year. Table 2 shows that in all nine species of trees (*R. regia* and *C. nucifera* were excluded as palms with a trunk diameter of more than 50 cm were rare), a higher percentage of trees with a trunk diameter of more than 50 cm had epiphytes on them. The difference between presence and absence of epiphytes was less obvious in the case of *E. saman*, *E. grandis* and *S. macrophylla*. *E. saman* had a high rate of infestation regardless of the diameter class while the other two species of trees were all more than 60 years old, and thus had their share of epiphytes. In addition to having a higher percentage of trees with epiphytes, older trees had more epiphytic species on them (Fig. 2). Of those trees sampled whose trunk diameter was more than 50 cm, 53% had three or more epiphytic species on them, compared to 24% of those trees with a diameter of 30–50 cm. Another point worth noting is that a higher percentage of the latter group had no epiphytes at all.

Table 3 lists the number of the various wayside trees that had only one epiphytic species. Of the 238 trees with only one epiphytic species, 65 had *D. piloselloides* while 83 had *D. crumenatum*. Looking at the data closer, it is

noted that of the 83 trees with the pigeon orchid, 43 are *S. macrophylla* and 23 *E. grandis*. Most, if not all the trees sampled belonging to these two species were more than 60 years old. The presence of *D. crumenatum* on trees of *S. macrophylla* and *E. grandis* thus indicates a later stage of succession. It is not a pioneer while *D. piloselloides* is, as this fern was usually found to be associated with relatively young trees. *P. longifolia* and *A. nidus* are also pioneers but these epiphytic ferns generally appear later than *D. piloselloides*.

DISCUSSION

In growing trees for shade, pollarding is generally practised to encourage branching. Two, three or even four branches may arise at the point of the cut. The bases of these branches form rain channels along which rain water flows down the trunk. In certain cases a depression develops where the branches meet and water collects here. Dead leaves together with dust blown off the road also accumulate here and along the rain channels, especially if the bark is rough and flaky. These sites form the centres of epiphytic colonization (Fig. 3-6). Other sites include bark fissures, axils of large branches, the base of the tree and wound scars (Oye, 1924). The first plants to appear are the blue-green algae, followed closely by the bryophytes (Barkman, 1958). Under local conditions *D. piloselloides* is the first vascular epiphyte to colonize the trees. This fern does not grow along the rain channels or in the depression at the base of the main branches where moisture is readily available, but rather on the trunk itself or the surface of the main branches (Fig. 7 and 10). Once established, this fern may spread and cover more areas of the bark, and in extreme case even the twigs and leaves. On *F. fragrans* trees the pioneer is *P. longifolia* instead of *D. piloselloides*. Both these ferns are crassulacean acid metabolism plants (Wong & Hew, 1976) and together with their succulent fronds and stellate hairs covering the abaxial surface, are apparently sufficiently adapted to such habitats.

The presence of depressions at the axils of the main branches of the trees, with the accumulation of soil, paves the way for the establishment of saplings of other wayside trees which are normally not epiphytic. These are the "epiphyta ephemeralis" of Hosokawa (1968). *Nephrolepis biserrata* (Sw.) Schott., basically a ground fern but common on oil palms (Sands, 1926), was also found, although sparsely, on a number of wayside trees. This fern can be classified as "epiphyta occasionis", while the strangling figs, *Ficus* spp., common on many trees (Fig. 5), are actually false epiphytes or the "hemiepiphytes" of Hosokawa (1968).

Humus collecting ferns like *A. nidus* and *P. coronarium* (Fig. 3-6 and 11-12), are later pioneers, preparing the way for other epiphytes: *D. denticulata* growing from the root mass of the former (Fig. 11), *V. ensiformis* growing under the shade of the fronds of *A. nidus*, and *Ophioglossum pendulum* Linn. growing from the nest of *P. coronarium* (Fig. 11).

The stag's horn fern, *P. coronarium*, a common epiphyte of rubber trees (Anon., 1955), is slowly getting scarce. In the present survey, this fern was observed on 0.5% of the trees examined while only nine years ago Johnson & Awan (1972) reported finding them on 60 out of the 150 *F. fragrans* trees they examined. Of the 150 such trees observed in the present survey (these trees need not necessarily be the same as the earlier ones) only one was found to harbour *P. coronarium*. Old nests of this fern usually have *O. pendulum* growing from them (Fig. 11), which competes with its host for the supply of water held

within the nest. It appears that as the *O. pendulum* grows larger, it absorbs most of the water from the nest resulting in the eventual death of the host (Holtum, 1954). It is possible that the sparsity of the stag's horn fern may be due to death of the old plants at a faster rate than sporeling establishment. However, it is probable that the drastic reduction of the fern's population has been the result of their being physically removed, as excess water dripping from the nest can encourage rotting of the branches. Also, it has been reported that the water held by the nest provides breeding ground for mosquitoes (Anon., 1955).

About 53% of the trees examined harboured some species of epiphyte or other. Forest trees apparently are less infested with vascular epiphytes. Davis & Richards (1933, 1934) recorded epiphytes on only 16% of trees more than 5 m high and 38% of trees more than 14 m high in a number of plots sampled from a high forest in Guyana. The figures for rain forests of Sarawak are 11% to 13% (Richards, 1936) and of Nigeria are 15% to 24% (Richards, 1939). According to Richards (1957), the number of epiphytic species on a single tree is seldom very large, from 13 species recorded in Nigeria to about 15 species in Guyana. This is comparable to the 18 species recorded from the sample of *E. saman* trees examined in this survey. On the other hand Eggeling (1947) has observed as many as 40–45 species of phanerogams and ferns on one tree in Uganda. The epiphytic flora on *Dipterocarpus oblongifolius* Bl. growing along the banks of small rivers in Peninsula Malaysia is still richer. Henderson (1935) recorded as many as 87 orchid species and 40 other phanerogams and ferns on such trees during an expedition up one of the small tributaries of Sungei Sat and Sungei Ketil in Kelantan.

The extent of epiphytic infestation of the local wayside trees depends on the nature of the bark, the nature of the crown and the mode of branching. A smooth bark reduces the chance of epiphytic establishment as it is unable to trap the propagules. *A. falcataria* has a very smooth bark (Fig. 9) and only in very old trees are there any epiphytes. The same situation is seen with *R. regia* (Fig. 8). Epiphytes only manage to establish at the base of the trunk when the numerous prop roots have emerged to break the smoothness of the bark, or on the trunk when the smooth surface has been damaged. At the other extremes are the rough and flaky bark of *E. saman* (Fig. 6 and 10), *E. grandis* (Fig. 7) and *S. macrophylla* (Fig. 4).

The abundance of epiphytes on *E. saman* is also due to the mode of branching and the structure of the crown. The main branches grow out at an angle of 50–80° to the main axis. The ends of the branches bear leafy shoots which form the thin layer of foliage making up the umbrella-shaped crown. The inside of the crown is spacious and devoid of leaves, and this allows sunlight and moisture to get to the branches, where the epiphytes usually are (Fig. 3). The branching of *P. indicus* and the structure of the crown on the other hand discourage epiphytic growth. The branches grow at an angle of 10–30° to the main axis and bear numerous, slender and leafy shoots which hang down into the interior of the crown. This results in a dense and narrow-domed crown which is obviously not conducive to epiphytic growth. Most of the epiphytes on *P. indicus* are found around the main forks of the branches where light and moisture are available.

The branching of *E. grandis* and *S. macrophylla* does not encourage epiphytic infestation as the branches grow up at an angle of 30–40°. Branching is sparse in these trees as they had not been planted for shade and thus not subjected to

pollarding. The richness of epiphytes on these two species of trees can be attributed to their age, most of which are at least 60 years old. In the case of *F. fragrans* the sparsity of epiphytes is attributed to the nearly vertical branches or the branches growing horizontally for a short distance before turning upwards. Such branching provides poor sites for epiphytic establishment. The deeply fissured bark without being flaky obviously does not help in the trapping of propagules.

Another factor that encourages epiphytic infestation is the availability of moisture around the branches where the epiphytes usually are. In most trees dew is precipitated on the coldest surfaces, that is, the leaves. Thus the leaves are thoroughly wet at night while the branches remain dry (Geiger, 1950). In the case of *E. saman*, the leaflets begin to fold about one and a half hours before sunset and do not open until the same time after sunrise (Corner, 1952). This permits dew to settle on the branches and thus provides a supply of moisture to the epiphytes even during dry periods. Also, when the sky is overcast, the leaflets similarly close. During any subsequent rain the branches are sure to get wet. With other broad-leaved trees however, a considerable proportion of the rain clings on to the leaves. If the rainfall is less than 10 mm the water flowing down the trunk is negligible (Geiger, 1950). Downflow begins only after the rainfall is heavy and even in this case only about 20% of the total rainfall flows down the trunk. With needle-leaved trees the amount of rain that clings on to the leaves is higher than in the case of broad-leaved trees. The downflow of the water among such trees is less than 5% of the total rainfall even in the heaviest of storms. This is probably the case with *C. equisetifolia* where the epiphytic flora is extremely poor. Only when such trees have been subjected to some form of pollarding and side branches have developed can one find any epiphytes on the branches or trunks.

ACKNOWLEDGEMENT

The assistance of Mr. Douglas Teow in photography is greatly appreciated.

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TABLE 1.
PERCENTAGE OCCURRENCES OF EPIPHYTIC SPECIES
ON 11 COMMON WAYSIDE TREES

EPIPHYTE	WAYSIDE TREE										
	<i>E. saman</i>	<i>E. grandis</i>	<i>S. macrophylla</i>	<i>P. pterocarpum</i>	<i>F. fragrans</i>	<i>P. indicus</i>	<i>A. auriculiformis</i>	<i>C. equisetifolia</i>	<i>C. nucifera</i>	<i>A. falcata</i>	<i>R. regia</i>
FERNS											
<i>Asplenium nidus</i> Linn.	47	50	38	14	6	23	17	11	2	1	1
<i>Davallia denticulata</i> (Burm.) Mett.	39	41	44	0	4	12	3	5	0	0	0
<i>Drymoglossum piloselloides</i> (Linn.) Presl.	34	15	7	25	3	20	41	6	4	1	3
<i>Drynaria sparsisora</i> (Desv.) Moore	13	1	3	0	1	1	0	0	0	0	0
<i>Nephrolepis biserrata</i> (Sw.) Schott	1	1	0	0	0	1	1	0	0	0	1
<i>Ophioglossum pendulum</i> Linn.	1	0	0	0	1	0	0	0	0	0	0
<i>Phymatodes scolopendria</i> (Burm.) Ching	13	5	7	0	1	3	0	1	0	0	0
<i>Platycerium coronarium</i> (Koenig.) Desv.	3	1	0	0	1	0	2	1	0	0	0
<i>Pyrrosia longifolia</i> (Burm.) Morton	18	8	3	2	27	6	2	4	0	2	0
<i>Pyrrosia</i> spp.	38	17	14	16	2	9	8	4	1	1	0
<i>Vittaria ensiformis</i> Sw.	16	11	1	0	1	7	0	0	0	0	0
PHANEROGAMS											
<i>Bulbophyllum vaginatum</i> (Lindl.) Rehb.f.	4	43	1	0	0	1	0	0	0	0	0
<i>Dendrobium crumenatum</i> Sw.	47	56	85	28	16	8	2	2	3	0	0
<i>Dischidia nummularia</i> R.Br.	6	9	6	17	3	3	1	1	2	0	0
<i>Dischidia rafflesiana</i> Wall.	1	1	0	3	0	0	0	0	0	0	0
<i>Ficus religiosa</i> Linn.	2	0	0	0	0	0	2	0	0	0	0
<i>Ficus</i> spp.	18	14	7	9	16	12	13	2	0	1	2
<i>Hoya ridleyi</i> King & Gamble	3	5	1	0	1	0	0	0	0	0	0
<i>Cordia cylindristachya</i> Roem & Schult.	1	0	0	0	0	0	0	0	0	0	0
<i>Acacia auriculiformis</i> A. Cunn. ex Bth.	0	0	0	0	1	0	0	0	0	0	0
<i>Cinnamomum iners</i> Reinw. ex Bl.	0	0	0	0	1	0	0	0	0	0	0
<i>Eugenia grandis</i> Wight	0	0	0	0	0	1	0	0	0	0	0
<i>Ptychosperma</i> sp.	1	0	0	0	0	0	0	0	0	0	0
No. of epiphytic fern species	11	10	8	4	10	9	1	1	3	4	3
No. of epiphytic phanerogam species	7	6	5	4	4	4	4	3	2	1	1
No. of "non-epiphytic" phanerogam species	2	0	0	0	2	1	0	0	0	0	0

TABLE 2.

PERCENTAGE OF OBSERVED TREES WITH EPIPHYTES

	Trunk diameters		**Number
	30-50 cm	>50 cm	Observed
<i>Enterolobium saman</i> Prain ex King	77	97	90/70
<i>Eugenia grandis</i> Wight	90	99	121/102
<i>Swietenia macrophylla</i> King	82	98	147/70
<i>Casuarina equisetifolia</i> J.R.&G.Forst.	14	43	114/30
<i>Peltophorum pterocarpum</i> Backer ex Heyne	58	100	78/18
<i>Albizzia falcataria</i> (L.) Fosberg			
<i>Pterocarpus indicus</i> Willd.	38	80	93/45
<i>Fagraea fragrans</i> Roxb.	36	82	89/61
<i>Acacia auriculiformis</i> A.Cunn.ex Bth.	34	100	86/36
<i>Roystonea regia</i> (H.B.K.) D.F.Cook	7	*	154/*
<i>Cocos nucifera</i> L.	12	*	200/*

* All the palms observed had trunk diameters of 30–50 cm.

** Number of trees observed with trunk diameters 30–50 cm / >50 cm

TABLE 3.

SINGLE EPIPHYTIC SPECIES INFESTATION:
NUMBER OF TREES OF THE VARIOUS TYPES AND SPECIES OF EPIPHYTES

[illegible]

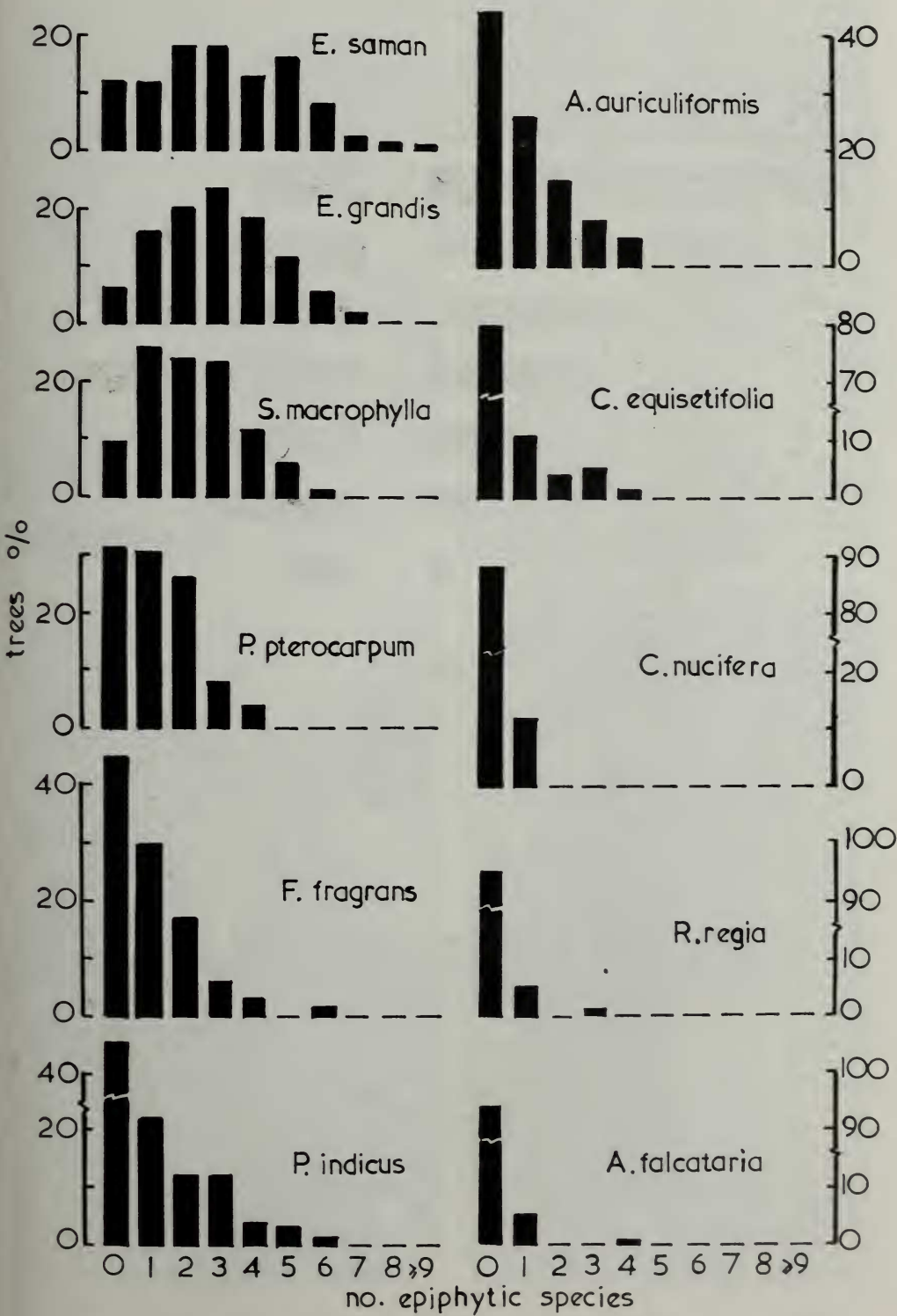


Fig. 1. Percentage occurrences of number of epiphytic species per tree for the 11 common wayside trees.

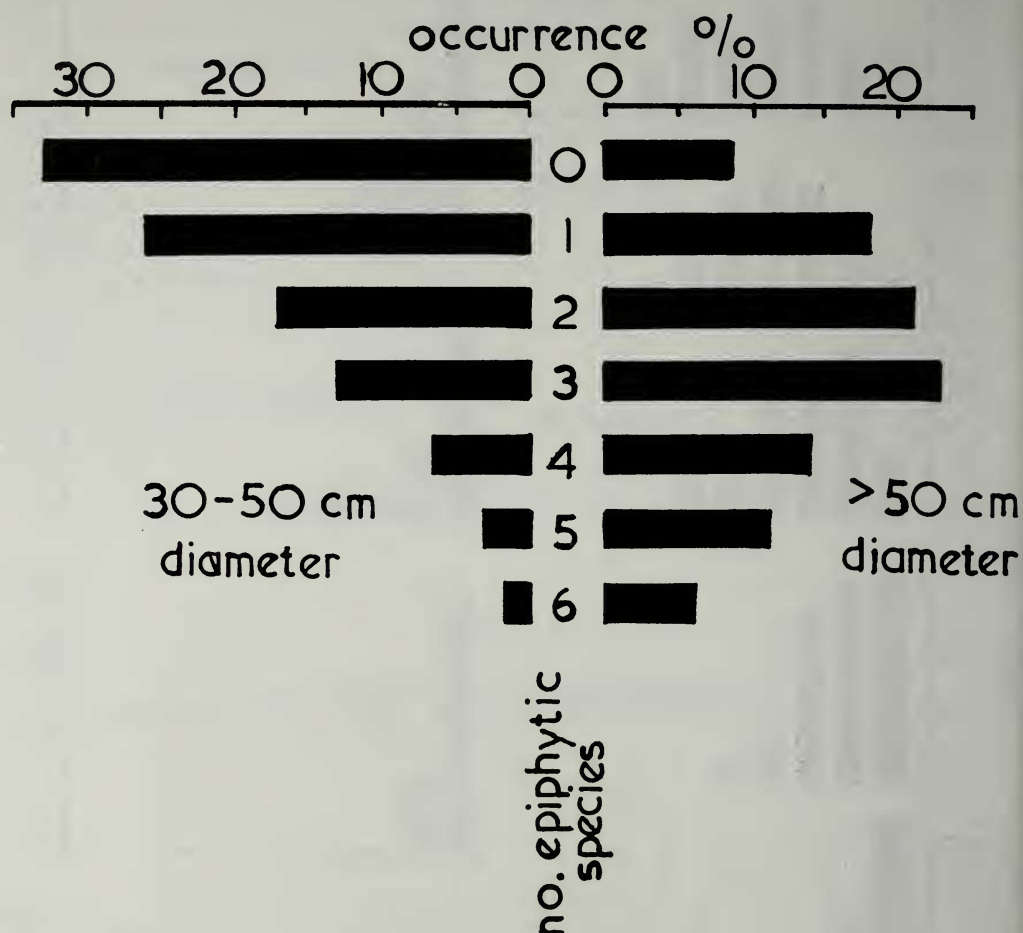


Fig. 2. Percentage occurrences of epiphytic species on trees with trunk diameters of 30-50 cm and >50 cm based on a survey of 704 and 402 trees respectively coming from seven species of tree (*E. saman*, *E. grandis*, *S. macrophylla*, *P. pterocarpum*, *F. fragrans*, *P. indiicus* and *A. auriculiformis*).

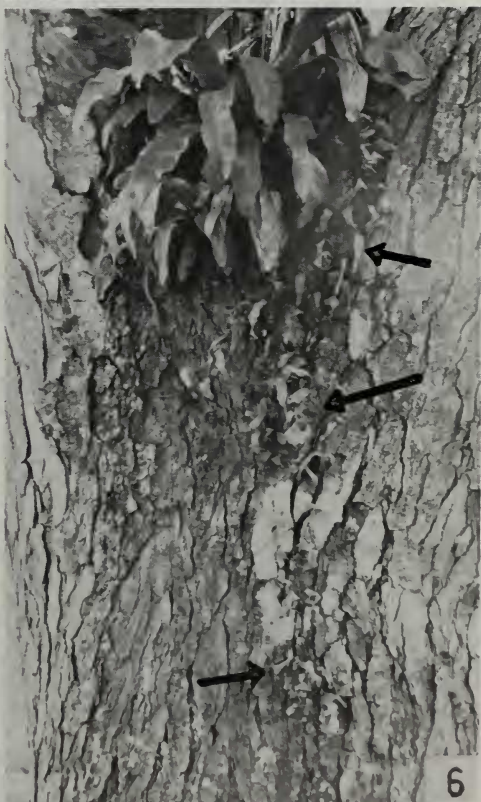


Fig. 3-6. Fig. 3. Nests of *Asplenium nidus* perching on the branches of the rain tree, *Enterolobium saman*. Fig. 4. An old nest of *Asplenium nidus* growing on the mahogany tree, *Swietenia macrophylla*. Note the flaky and scaly bark. Fig. 5. An old *Acacia auriculiformis* tree infested with *Asplenium nidus* and *Ficus* sp. Fig. 6. Close up of *Enterolobium saman* trunk to show the establishment of *Asplenium nidus* along the rain channel and *Pyrrosia* sprailing along the trunk (arrowed) with wilted fronds as a result of drought.

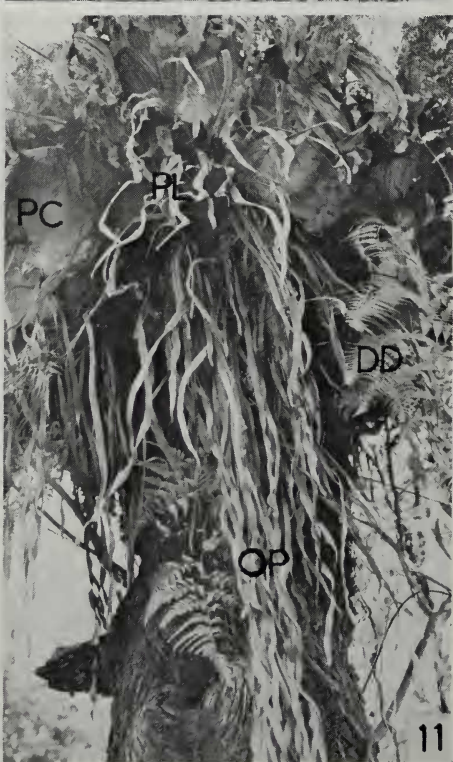
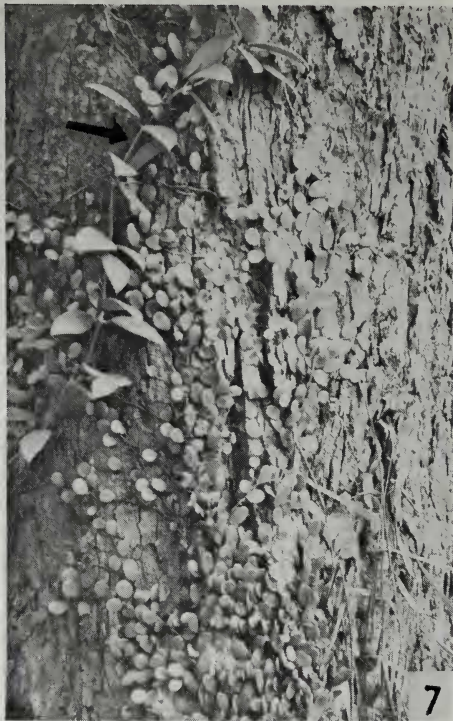


Fig. 7-12. Fig. 7. *Drymoglossum piloselloides* growing on the rough and flaky bark of *Eugenia grandis*. Towards the left (arrowed) is *Hoya ridleyi*. Fig. 8. Trunk of *Roystonea regia* to show the smooth surface. Fig. 9. Smooth bark of *Albizia falcataria*. Fig. 10. Close up of *Enterolobium saman* trunk with its shallowly fissured and flaky bark and recent establishment of a young *Asplenium nidus* (arrowed, left) and *Drymoglossum piloselloides* (arrowed, right). Fig. 11. An old *Fagraea fragrans* tree infested with old nests of *Platycerium coronarium* (PC) from which grow *Ophioglossum pendulum* (OP), *Pyrrosia longifolia* (PL) and *Davallia denticulata* (DD). Fig. 12. The stag's horn fern, *Platycerium coronarium* with its nest and pendulous fronds.